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MEMORANDUM

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NATURAL ENVIRONMENT DESIGN REQUIREMENTS  
FOR THE SORTIE MODULE

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*George C. Marshall Space Flight Center  
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16. ABSTRACT  This report gives the natural environment design requirements for the Sortie Module. Since this module is carried as "cargo" to orbital altitudes in the Space Shuttle bay, orbital environmental impacts are the main concern of the report.			
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## 1.0 PURPOSE AND SCOPE

The definition of natural environment design requirements for Sortie Module missions.

## 2.0 NATURAL ENVIRONMENT - GENERAL

The natural environment criteria given in this report are consistent with those specified for the Space Shuttle system and will be used for design of the Sortie Module with respect to radiation atmospheric characteristics at orbital altitudes, and other pertinent natural environment requirements. Design value requirements of natural environment parameters not specifically defined below will be obtained from NASA TM X-64587, "Terrestrial Environment (Climatic) Criteria Guidelines for Use in Space Vehicle Development, 1971 Revision," dated May 10, 1971 [1], and NASA TM X-64627, "Space and Planetary Environment Criteria Guidelines for Use in Space Vehicle Development, 1971 Revision," dated November 15, 1971 [2], and subsequent addenda to those documents. The Sortie Module will be subject to environmental factors peculiar to the Space Shuttle during assembly, checkout, launch, and attainment of orbital positioning prior to removal of the Sortie Module from the Shuttle bay; therefore, appropriate Shuttle documents should be consulted when the Sortie Module is "cargo" in the Space Shuttle.

Natural environmental data not given in the above and required in design or mission analyses for the Sortie Module will be requested from or approved by the MSFC Aerospace Environment Division through the cognizant NASA Contract Representative prior to use.

## 3.0 NEUTRAL ATMOSPHERE - ORBITAL ALTITUDES

3.1 The Jacchia 1970 Model Atmosphere will be used. See Appendix B, NASA TM X-64627 for details.

3.2 The design steady state values of the orbital neutral atmospheric gas properties shall be calculated using a value of 230 for the mean 10.7 cm solar flux and a geomagnetic index ( $a_p$ ) of 20.3 with a local time of day of 0900 hr as inputs to the Jacchia 1970 Model Atmosphere.

3.3 The design short-time extreme values of the atmospheric gas properties shall be calculated using a value of 230 for the mean 10.7 cm solar flux and a geomagnetic index ( $a_p$ ) value of 400, and a local time of day of 1400 hr as input to the Jacchia 1970 Model Atmosphere. These orbital neutral atmospheric gas property values represent an estimate of the conditions that may occur for a short period of time (12 to 36 hours) during an extremely large magnetic storm.

3.4 Exosphere (37,000 km Geosynchronous Orbital Altitude) - The data given in Section 2.2.2 of NASA TM X-64627 shall be used.

#### 4.0 CHARGED PARTICLES

The electron density values and data in Section 2.3 of NASA TM X-64627 shall be used.

#### 5.0 RADIATION

In addition to the following, use Section 2.4 of NASA TM X-64627. The Sortie Module shall be designed to provide necessary protection to insure the safe dosage limits of the equipment and crew are not exceeded.

5.1 Galactic Cosmic Radiation - Galactic cosmic radiation consists of low intensity, extremely high energy charged particles. These particles, about 85 percent protons, 13 percent alphas, and the remainder heavier nuclei, bombard the solar system from all directions. They have energies from  $10^8$  to  $10^{19}$  electron volts (ev) per particle and are encountered essentially everywhere in space. The intensity of this environment in "free-space," e.g., outside the influence of the earth's magnetic field, is relatively constant (.2 to .4 particles per square centimeter per steradian per second) except during periods of enhanced solar activity when the fluxes of cosmic rays have been observed to decrease due to an increase in the strength of the interplanetary magnetic field which acts as a shield to incoming particles. Near the earth, cosmic rays are similarly influenced by the earth's magnetic field resulting in a spatial variation in their intensity. The extreme of the galactic

cosmic ray environment is at sunspot minimum. The environment is constant and may be scaled down to 24 hours. See Section 2.4.1 of NASA TM X-64627 for additional data on this subject.

Estimates of the daily cosmic ray dose for the various orbits are shown in Table 1. These should be considered in the Sortie Module design studies.

Table 1. Galactic Cosmic Ray Dose Rates (REM/Day)

	255 n.m. 55° Incl.	200 n.m. Polar	Geo- synchronous
Solar Maximum	0.005	0.008	0.024
Solar Minimum	0.008	0.013	0.036

5.2 Trapped Radiation - The trapped radiation environment will be taken from most recent data of NASA SP-3024 (currently in six volumes) or from the TRECCO computer code available from the National Space Science Data Center, NASA/Goddard Space Flight Center, and merged with trajectory information to find particle fluxes and spectra. The fluxes and spectra will be converted to dose by data and/or computer codes provided by MSFC/S&E-SSL-NR (see Section 2.4.2 of NASA TM X-64627).

5.2.1 Near-Earth Environment - The radiation belts trapped near the earth are approximately azimuthally symmetric, with the exception of the South Atlantic anomaly where the radiation belts reach their lowest altitude. The naturally occurring trapped radiation environment in the anomaly region remains fairly constant with time although it does fluctuate with solar activity. Electrons will be encountered at low altitudes in the anomaly region as well as in the auroral zones.

5.2.2 Synchronous Orbit Altitude Environment - The trapped proton environment at synchronous orbit altitude is of no direct biological significance, but may cause deterioration of material

surfaces over long exposure times. The proton flux at this altitude is composed of only low energy protons (less than 4 Mev) and is on the order of  $10^5$  protons/cm<sup>2</sup>-sec. The trapped electron environment at synchronous altitude is characterized by variations in particle intensity of several orders of magnitude over periods as short as a few hours. However, for extended synchronous altitude missions, a local time averaged environment can be used. See Section 2.4.2.2 of NASA TM X-64627 for additional data.

5.3 Solar Particle Events - Solar particle events are the emission of charged particles from disturbed regions on the sun during solar flares. They are composed of energetic protons and alpha particles that occur sporadically and last for several days. The free-space particle event model to be used for Sortie Module orbital studies is given in Section 2.4.3.1 of NASA TM X-64627.

5.4 Radiation Dose Limits - Table 2 (p. 5) lists the allowable radiation limits for the flight crews to be used for all applicable program considerations. These values are based on information contained in "Radiation Protection Guides and Constraints for Space - Mission and Vehicle - Design Studies Involving Nuclear Systems," a report of the Radiobiological Advisory Panel of the Committee on Space Medicine, Space Science Board, National Academy of Sciences. The Radiobiological Advisory Panel's concept of a primary reference risk is adopted and a unit reference risk is considered acceptable for the subject manned space flight programs.

## 6.0 METEOROID

The Sortie Module shall be designed for at least a 0.95 probability of no puncture during the maximum total time in orbit using the meteoroid model defined in Section 2.5.1 of NASA TM X-64627.

6.1 Meteoroid Impact - Sortie Module meteoroid impact requirements shall be as specified below:

a. Pressure Loss - The Sortie Module manned volume, when utilized, shall be protected from meteoroid impact damage which would result in pressure loss when subjected to the meteoroid flux model as defined in NASA TM X-64627.

Table 2. Radiation Exposure Limits and Exposure Rate Constraints for Unit Reference Risk

Constraints in REM	(REM) Bone Marrow (5 cm)	Skin (0.1 mm)	Eye (3 mm)	Testes <sup>2</sup> (3 cm)
1 yr avg. daily rate	0.2	0.6	0.3	0.1
30-day maximum	25	75	37	13
quarterly maximum <sup>1</sup>	35	105	52	18
yearly maximum	75	225	112	38
career limit	400	1200	600	200

NOTE: These exposure limits and exposure rate constraints apply to all sources of radiation exposure. In making trade-offs between man-made and natural sources of radiation, adequate allowance must be made for the contingency of unexpected exposure.

b. Functional Capability - The Sortie Module shall provide protection against loss of functional capability of selected critical items when subjected to the meteoroid flux model as defined in NASA TM X-64627. The probability of no penetration shall be assessed on each item dependent upon function criticality.

## 7.0 ASTRODYNAMIC CONSTANTS

The values given in Sections 1.6 and 2.7 of NASA TM X-64627 shall be used.

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<sup>1</sup>May be allowed for two consecutive quarters followed by six months of restriction from further exposure to maintain yearly limit.

<sup>2</sup>These dose and dose rate limits are applicable only where the possibility of oligospermia and temporary infertility are to be avoided. For most manned space flights, the allowable exposure accumulation to the Germinal Epithelium (3 cm) will be the subject of a risk/gain decision for particular programs, missions, and individuals concerned.

## 8.0 EARTH-VIEWING MISSIONS - GLOBAL CLOUD MODEL

Consult NASA Contractor Report NASA CR-61345, "Development of a Global Cloud Model for Simulating Earth-Viewing Space Missions," April 7, 1971, Allied Research Associates, Inc., Virginia Road, Concord, Massachusetts [3].

## REFERENCES

1. Daniels, Glenn E., ed., 1971: Terrestrial environment (climatic) criteria guidelines for use in space vehicle development, 1971 revision. NASA TM X-64587.
2. Smith, R. E., ed., 1971: Space and planetary environment criteria guidelines for use in space vehicle development, 1971 revision. NASA TM X-64627.
3. Greaves, James R., David B. Spiegler and James H. Willand, 1971: Development of a global cloud model for simulating earth-viewing space missions. Allied Research Associates, Inc., Virginia Road, Concord, Mass., NASA CR-61345.

APPROVAL

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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